A buffer solution helps to maintain a constant pH, it is composed of a weak acid (or base) + its conjugate base (or acid) in equal quantities.
If a buffer solution is diluted the pH is not affected as the $\frac{[acid]}{[base]}$ ratio remains same.

$H^+_{(aq)} + HCO^-_{3(aq)} \rightleftharpoons H_2CO_{3(aq)}$

$OH^-_{(aq)} + H_2CO_{3(aq)} \rightleftharpoons HCO^-_{3(aq)}$

buffer zone the pH range ($pK_a \pm 1$) of which the buffer solution is effective

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Calculate the pH of a buffer solution when 70ml of $0.15\ mol\,L^{-1}$ of $NaCH_3COO$ is added to 30ml of $0.15\ mol\,L^{-1}$ CH_3COOH

$K_a(CH_3COOH) = 1.74 \times 10^{-5}$

$\frac{70}{100} \times 0.15 = [CH_3COO^-]$ (0.105) $\quad \frac{30}{100} \times 0.15 = [CH_3COOH]$ (0.045)

$K_a = \frac{[H_3O^+][0.105]}{0.045} = 1.74 \times 10^{-5}$

$[H_3O^+] = \frac{(1.74 \times 10^{-5})(0.045)}{(0.105)}$

$= 7.46 \times 10^{-6}$

$pH = -\log(7.46 \times 10^{-6}) = 5.13 = ANS$

Equal volumes of 0.2m aqueous solutions of ammonium chloride and ammonia are combined to form a buffer solution $m(NH_4Cl) = 53.5 g/mol^{-1}$.

i) write the equations if small amount acid or base added
ii) calculate the pH of the buffer soln $K_a(NH_4^+) = 5.75 \times 10^{-10}$
iii) calculate the pH if 2ml of 1m HCl added to 1 litre of buffer
iv) calculate pH of new buffer if 5g NH_4Cl dissolved in 1 litre of original buffer.

i) $H_3O^+_{(aq)} + NH_{3(aq)} \rightleftharpoons NH^+_{4(aq)} + H_2O_{(l)}$ $\quad OH^-_{(aq)} + NH^+_{4(aq)} \rightleftharpoons NH_{3(aq)} + H_2O_{(l)}$

ii) equal volumes, dilution factor of 2 $[NH_3] = [NH_4^+] = 0.1m$

$pH = pK_a = -\log K_a = -\log[H_3O^+]$ $\quad K_a = \frac{[H_3O^+][A^-]}{[HA]}$

$-\log(5.75 \times 10^{-10}) = 9.24$

iii) $n(HCl) = c \times V = 1 \times 0.002 = 0.002$ moles

This was added to buffer + reacts with NH_3 to form NH_4^+

new $[NH_3] = 0.1 - 0.002 = 0.098$

new $[NH_4^+] = 0.1 + 0.002 = 0.102$

$pH = pK_a + \log\frac{0.098}{0.102} = 9.24 - 0.017 = 9.22$ (9.24 ↑ from pH above)

iv) $n(NH_4^+)$ added $= n(NH_4Cl)$ added $= \frac{5g}{53.5 g/mol^{-1}} = 0.093$ moles added to 1 litre

$[NH_3]$ still $\sim 0.1\ mol\,L^{-1}$

new $[NH_4^+] \sim 0.1 + 0.093 = 0.193$

$pH = pK_a + \log\frac{0.1}{0.193} = 9.24 - 0.29 = 8.95$

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buffer calculations

$HA + H_2O \rightleftharpoons H_3O^+ + A^-$

$K_a = \frac{[H_3O^+][A^-]}{[HA]}$ ← in a buffer concs are equal

$K_a = [H_3O^+]$

$pK_a = pH$

} because $pH = -\log[H_3O^+]$, $pK_a = -\log K_a$